

5. Canola

5.1 Background

Canola is a member of the *Brassica* Family, which includes broccoli, cabbage, cauliflower, mustard, radish, and turnip. It is a variant of the crop rapeseed. Grown for its seed, the seed is crushed for the oil contained within. After the oil is extracted, the by-product is a protein-rich meal used by the intensive livestock industry.

In the 1990s canola production increased dramatically due to new disease resistant varieties (Black Leg Resistance) and strong oilseed prices compared to wheat and wool. Australia has a production land base able to increase canola, though low oilseed prices could restrict expansion.

Canola is a very small seed, which means sowing depth must be controlled to minimise patchy germination. The current sowing practice is to cover the seed lightly with soil, which ensures more protection from drying out after germination.

Canola is generally sown in autumn (late April/early May), develops over winter, flowers in the spring and is harvested early summer (late November/early December) with a growing period of around 180-200 days

Climatic effects such as sudden heat waves can reduce yields and hot dry conditions can limit oil content. Summer weather ensures low moisture (less than 6%) at harvest. Carry-in stocks of canola are minimal because of a lack of on-farm storage.

Canola is a good rotational crop, acting as a break crop for cereal root diseases. However for disease-related reasons, a rotation period of 3-5 years is required for canola crops. Moreover, if on-going research on combating fungal root disease in wheat by seed inoculation proves successful, the land area available for growing canola will come under pressure when canola prices fall.

5.1.1 Canola alternatives

CSIRO has a research program on the use of linola as a substitute for canola (A. Green, CSIRO Plant Industries, pers. comm.) and a joint venture with United Grain Growers of Canada for the development and commercialisation of the crop. Linola is a form of linseed that was developed using conventional plant breeding to make the oil more suitable for edible uses, particularly for cooking oil. Linseed normally has a very high level of linolenic acid, which makes it oxidatively unstable and prevents its use in cooking, particularly commercial cooking (but gives it the drying properties associated with its traditional industrial usage). CSIRO reduced linolenic from 50% down to 3% and consequently raised linoleic up to 65-70%. This makes "linola" oil equivalent in composition and function to high-linoleic sunflower or safflower oils. Green (pers. comm.) would expect linola oil to perform the same as those oils in biodiesel applications.

5.2 Full Fuel-Cycle Analysis

5.2.1 Tailpipe

We are unable to find any tailpipe emissions data for heavy vehicles using pure canola oil. It is over a decade since research was undertaken on the use of pure vegetable oils, such as canola, as heavy-vehicle fuels. Though it is possible to modify diesel engines to run on pure vegetable oils (as discussed in the section on viability and functionality) the consensus of the industry is that biodiesel is a superior fuel. This view was expressed by a number of stakeholders verbally and in writing.

Part 2 Details of Fuels

5.2.2 *Upstream*

Details of canola seed production and processing are given in the chapter that deals with biodiesel.

The upstream emissions for canola oil will be the same as those for canola biodiesel (canola ethyl-ester) except that no transesterification phase is required.

5.2.3 *Results*

At present pure canola oil is not a viable automotive fuel (see Section 5.3). Thus no results are presented.

5.3 *Viability and Functionality*

According to material supplied by P. Calais of Murdoch University, though the power output and tailpipe emissions using plant or animal oils are in most cases comparable with the power output and the emissions when running on petroleum diesel fuel, the main problem encountered has been the higher viscosity of the oils causing difficult starting in cold conditions, the gumming up of injectors, the coking-up of valves and exhaust, and the often high melting or solidification point of many vegetable and animal fats and oils. (Pullan et al, 1981)

The viscosity of plant and animal fats and oils varies from hard solids to light oils at room temperature. In most cases, these 'oils' are actually a solution of various fatty acids, often with the various components having widely varying melting points. This may give the oil a temperature range over which solidification occurs, with the oil gradually thickening from a thin liquid, through to a thick liquid, then a semi-solid and finally to a solid.

High melting points or solidification ranges can cause problems in fuel systems such as partial or complete blockage as the oil thickens and finally solidifies when the ambient temperature falls (Pullan et al., 1981). Though this also occurs with petroleum-based diesel, particularly as the temperature falls below about $\sim 10^{\circ}\text{C}$ for 'summer' formulations and $\sim -5^{\circ}\text{C}$ for 'winter' diesels, it is relatively easy to control during the refining process and is generally not a major problem.

Most vegetable oils and some animal oils have 'drying' or 'semi-drying' properties and it is this which makes many oils such as linseed, tung and fish suitable as the base of paints and other coatings. But it is also this property that further restricts their use as fuels.

Drying results from the double bonds in the oil molecules which can be easily broken by atmospheric oxygen converting the fatty acid into a peroxide. Cross-linking at this site can then occur and the oil irreversibly polymerises into a plastic-like solid (Cole et al., 1977).

In the high temperatures commonly found in internal combustion engines, the process is accelerated and the engine can quickly become gummed-up with the polymerised oil. With some oils, engine failure can occur in as little as 20 hours (Duke, 1983).

The traditional measure of the degree of bonds available for this process is given by the 'Iodine Value' (IV) and can be determined by adding iodine to the fat or oil. The amount of iodine in grams absorbed per 100 ml of oil is then the IV. The higher the IV, the more unsaturated (the greater the number of double bonds available) is the oil and the higher the potential to 'gum up' when used as a fuel in an engine.

Though some oils have a low IV and are suitable without any further processing other than extraction and filtering, the majority of vegetable and animal oils have an IV which does not permit their use as a neat fuel.

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Generally speaking, an IV of less than about 25 is required if the neat oil is to be used in unmodified diesel engines and this severely limited the types of oil that can be used as fuel. Table 1 lists various oils and some of their properties.

The IV can be easily reduced by hydrogenation of the oil (reacting the oil with hydrogen), the hydrogen breaking the double bond and converting the fat or oil into a more saturated oil and reducing the tendency of the oil to polymerise. However this process also tends to increase the melting point of the oil and converts the oil into margarine.

As can be seen from Table 5.1, only coconut oil has an IV low enough to be used without any special precautions in a unmodified diesel engine. However with a melting point of 25°C, the use of coconut oil in cooler areas would obviously lead to problems.

Table 5.1
Melting point and Iodine Values of oils

Oil	Approx. melting point °C	Iodine Value
Castor oil	-18	85
Coconut oil	25	10
Cotton seed oil	-1	105
Linseed oil	-24	178
Olive oil	-6	81
Palm oil	35	54
Palm kernel oil	24	37
Peanut oil	3	93
Rapeseed oil	-10	98
Soybean oil	-16	130
Sunflower oil	-17	125
Tung oil	-2.5	168
Beef tallow		50
Mutton tallow	42	40
Sardine oil		185

Source: *CRC Handbook of Chemistry and Physics, 64th and 76th Ed. pp D-221*

All of these problems can be at least partially alleviated by dissolving the oil or hydrogenated oil in petroleum diesel. Linseed oil for example, could be mixed with petroleum diesel at a ratio of up to 1:8 to give an equivalent IV in the mid-twenties. Likewise coconut oil can be thinned with diesel or kerosene to render it less viscous in cooler climates. Obviously the solubility of the oil in petroleum also needs to be taken into account. Another method is to emulsify the oil or fat with ethanol.

Most vegetable oils are a mixture of different esters such as oleic acid (main constituent of olive oil), ricinoleic acid (main constituent of castor oil), linoleic acid and linolenic acid (main constituents of linseed oil), palmitic acid (main constituent of palm kernel oil) and so on. In an analogous way to that in which crude oil is refined to make a useable automotive fuel, canola oil needs to be transesterified to make an automotive fuel that is useable in unmodified diesel engines. When the oil is processed in a transesterification process, the various fatty acids react with the alcohol to form a mixture of lighter esters and glycerol. The name of the specific fuel is called after the plant (or animal) source plus the alcohol. Made from rapeseed oil and methanol, the biodiesel is called Rape Methyl Ester (RME), from canola oil and ethanol, Canola Ethyl Ester (CEE), and from used McDonald's cooking oil and ethanol or methanol, McDiesel.

Nevertheless, there is a niche market, mainly in Germany and Austria, in the conversion of diesel vehicles to run on vegetable oil. One example is that of <http://www.elsbett.com/gd/tuniinfe.htm> in Germany.

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5.4 *Health Issues*

The health issues associated with the use of canola oil in a diesel engine are not known.

5.5 *Environmental Impact and Benefits*

The environmental issues associated with the use of canola oil in a diesel engine are not known.